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Economic Growth and Agriculture's Relative Decline: Implications of Political Economy of Agricultural Policies

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Abstract

Economic importance of the agricultural sector tends to decline relatively to other sectors in a growing economy. The most notable demand-side factor is Engel's Law, indicating the proportion of income spent on food declines as per capita income increases with economic growth. Supply-side factors include differential rates of technical change between sectors and changes in relative factor supplies with economic growth. Engel's Law becomes less important in the case of an economy open to international trade. It has been commonly observed that most industrial countries have protectionist policies to support agriculture, while less developed countries discriminate against agriculture. In recent years, economists have looked beyond the traditional welfare maximization perspective to explain changes in agricultural policy as economic growth occurs, following a political economic approach. Hence, a further complicating factor is the possibility that a contracting agricultural sector under economic growth tends to endogenously induce a policy bias in favor of agriculture that may end up offsetting the tendency toward an agricultural contraction. Agricultural protection policies, however, have recently come under criticism in the Uruguay Round of GATT (WTO after 1995) negotiations. The UR Agreement on Agriculture focuses on reversing agricultural protection trend, and hence adds more dimensions into political economy determinants of agricultural policy making process.

This study analyzes how the relative economic importance of the agricultural sector in a growing economy is determined by the factors associated with economic development. We develop a two-sector general equilibrium model and explain the mechanisms through which both economic and political factors affect the evolution of agriculture's relative importance in the context of economic growth. We conduct a simulation analysis to investigate the hypothesis that growth-induced agricultural support policies can generate positive economic effects that will prevent or reduce agriculture's relative decline with economic growth. The results of various policy scenarios support our hypothesis. The analysis is taken further by conducting an empirical study. A simultaneous equations model is developed and estimated that explicitly takes into account the effect of endogenously determined agricultural protection, using data from six postwar fast-growing Asian economies for the period 1955-96 (before 1997 Asian Financial Crisis). The results show that agriculture's GDP (and labor) share is a function of the real per capita GDP level, and confirm a relative decline in agriculture with economic growth. The hypothesis that agriculture's relative decline is not inevitable is also confirmed by the estimation results.

Key words: Agriculture's Relative Share, Economic Growth, Endogeneity of Policy Shifts, Agricultural Protection, Engel's Law, UR Agreement on Agriculture, Asian Economies.

Introduction

Agriculture tends to decline relatively to other sectors in terms of its share in total gross domestic product (GDP) and of total employment in a growing economy. Both demand and supply-side factors account for this tendency. The most notable demand-side factor is Engel's Law, i.e., income elasticity of demand for food is less than unity. Engel's Law implies the proportion of income spent on food declines as per capita income increases with economic growth. Supply-side factors include differential rates of technical change between sectors and changes in relative factor supplies. The rapid development of new farm technologies over the past decades, for instance, has contributed to expanding food supplies per unit of land and labor and thus reducing resource use in agriculture given an inelastic food demand. Change in relative factor supplies is another important factor implied by the Rybczynski theorem (1955) which indicates that an increase in capital per worker as economic growth occurs will lead to a disproportionate increase in the output of the more capital-intensive, e.g. manufacturing, sector, at the expense of the more labor-intensive, e.g. agricultural sector, assuming constant relative commodity prices and full employment.

While Engel's Law explains the relative decline of agriculture in a global or a closed economy, its influence becomes less important in the case of an economy open to international trade. According to the theory of international trade, an economy endowed with favorable conditions for agriculture will exploit its comparative advantage in agriculture by specializing in agricultural production for exports and hence is not constrained by an inelastic domestic demand for agricultural products. A further complicating factor is the possibility that a contracting agricultural sector under economic growth tends to endogenously induce a policy bias in favor of agriculture that may end up offsetting the tendency toward an agricultural contraction. It has been commonly observed that most industrial countries have protectionist policies to support agriculture, while less developed countries discriminate against agriculture. Many studies have examined and addressed a positive relationship between economic growth and agricultural protection (Bale and Lutz, 1981; and Anderson and Hayami, 1986). Some studies have looked beyond the traditional welfare maximization perspective to explain changes in agricultural policy as economic growth occurs, following a political economic approach. These have asserted that structural changes associated with economic development endogenously generate policies to support and protect the agricultural sector (Olson, 1965, 1985; Becker, 1983; de Gorter and Tsur, 1991; and Swinnen, 1994).

The subject of agricultural development in developing and developed economies has been studied and documented in an enormous literature. However, one finds few attempt in the literature to provide a theoretical analysis that systematically examines the functioning of both economic and political factors underlying the changing relative importance of the agricultural sector in a growing closed/open economy. There is also a lack of empirical studies that provide estimates of the impacts of related factors on changing agriculture's relative size, which explicitly take into account the interrelationship between economic and policy variables in the context of economic growth.

During the past decades, many Asian economies have experienced rapid economic growth, including Japan, the "Four Tigers" (Taiwan, South Korea, Hong Kong and Singapore) and the newly industrialized countries of Southeast Asia (Thailand, Malaysia, and Indonesia).¹ The decline in the relative importance of agriculture has been most dramatic in the three densely populated, resource-poor East Asian economies, namely, Japan, South Korea, and Taiwan. These countries appear to have lost their comparative advantage in primary products at a relatively early stage of their economic development. In comparison, the three traditional agricultural-exporting Southeast Asian economies-- Thailand, Malaysia, and Indonesia-- are endowed with relatively rich land and natural resources. They too have witnessed a relative decline in agriculture, but it has been less

¹ They are identified (before the current Asian financial crisis) as High-Performing Asian Economies (HPAEs) in the landmark World Bank policy research report, entitled "The East Asian Miracle: Economic Growth and Public Policy," (1993). Hong Kong and Singapore almost entirely lack agricultural sectors and thus are excluded from this study.

rapid. Among other things, these Asian economies have differed considerably in the degree of protection given to agriculture through pricing and trade measures and in the evolution of protection over time. They hence provide a suitable empirical basis for this study.

The objectives of this article are threefold. First, it is intended to provide a theoretical analysis that examines the mechanisms through which factors, both economic and political, determine agriculture's relative importance in a growing open economy. Secondly, we develop a simulation model to examine the plausibility that agricultural supportive policies generate economic effects to offset agriculture's relative decline in a growing economy. Thirdly, we conduct an empirical study to quantify the effects of the factors underlying agriculture's relative size, in which a simultaneous equations model is estimated using data from six fast-growing Asian economies under study. The structure of the article is organized as follows. In the next section, we present a review of literature on agriculture's relative decline and agricultural policy shifts with economic growth. Section 3 provides a theoretical analysis to lay the foundation for both simulation and empirical analyses. In section 4, the simulation experiments are carried out for various scenarios of policy changes to examine whether agriculture's relative decline may not be inevitable with agricultural policy support. Section 5 presents an econometric analysis that empirically quantifies the impacts of major factors on agriculture's relative importance with data collected for six fast-growing economies in Asia over the past decades. In the final section, a summary is given and conclusions are drawn from this study.

Review of Literature

a) A Relative Decline of Agriculture in a Growing Economy

A paper by Anderson (1987) explains why agriculture declines with economic growth using standard economic theory and empirical realities, arguing that agriculture tends to decline even in economies with a strong comparative advantage in agriculture. In Anderson's paper, however, the impact of agricultural protection that likely offsets a contracting agricultural sector is not analyzed. Martin and Warr (1993) use a simple structural model of a supply-side economy that identifies three potential proximate factors accounting for the relative decline of agriculture in the Indonesian economy: i) changing relative prices, ii) differential rates of technical change, and iii) changing relative factor supplies. Their empirical analysis uses the approach of an error correction mechanism and shows that the relative price of agricultural output had comparatively little impact on the decline in agriculture's share, while technical change had a significantly positive effect on agriculture's share, thereby offsetting the contraction of the agricultural sector. A study by Schiff and Valdés (1992) provides estimates of price discrimination against agriculture and examines how agricultural price intervention affects foreign exchange earnings, agricultural output and income distribution in eighteen developing countries for the period 1960-84. Over the years, the governments of these countries influenced agricultural prices both directly, through agricultural sector policies, and indirectly, through industrial protection and macroeconomic policies that tax agriculture relative to other sectors of an economy. They show that the growth rate of agriculture can be affected by relative agricultural prices (agriculture's terms of trade) which have been highly influenced by countries' general and agricultural policies. Using a simple regression estimation they show an average annual increase in agricultural GDP growth of 0.61 percent by removing all price interventions (mostly, taxation of agriculture) for those eighteen countries.

b) Explaining Agricultural Policy Shifts: The Political Economy Approach

The observed tendency of policy shift from discriminating against farmers in poor countries to subsidizing farmers in rich countries has attracted the interest of economists to explain the nature and causes of such agricultural protection patterns in a political-economic framework. The political economy analysis differs from the conventional welfare maximization perspective in that the latter assumes that a benevolent government intervenes in the private economy to correct market failures.

The political economy approach emphasizes instead the allocation of public resources in the political market where each agent interacts based on his own interest. These agents, including politicians, voters, and pressure or lobbying groups, are assumed to be rational and seek to maximize their objective functions. That is, political support is maximized by politicians; individual welfare by voters; and benefits by pressure or lobbying groups. The equilibrium occurs where the marginal political value of resources transferred from opposing forces is balanced out. In so doing, the political economic models consider explicitly the agents' behavior in interrelated political and economic markets and endogenously derive government preferences and policy determination.

The *pressure group (or lobbying) models* and *voting models* are two major strands of the political economic models. In the spirit of Olson's (1965) theory of collective action and Becker's (1983) theory of competition among pressure groups for political influence, the pressure group models in general emphasize the organization costs and free-rider effects while ignoring the role of politicians by implicitly assuming politicians would transmit the political pressure from active groups accordingly. Voting models, on the other hand, focus on politicians' search for political support from voters to increase the chance of remaining in office by supplying policies that assist particular groups (see de Gorter and Tsur, 1991; and Swinnen, 1994).

i) The Pressure Group (Lobbying) Model

Based on what he refers to as 'the numbers paradox', wherein agriculture is exploited in countries with large agricultural populations while it is subsidized in countries with small agricultural populations, Olson (1965, 1985, 1990) emphasizes organization costs and farmer numbers in explaining price policy bias in agriculture of developing and developed countries. He argues that a policy shift to protect agriculture is more likely to occur in a society with more efficient political organization of farmers due to a reduction in the number of farmers and a mitigated free-rider problem associated with the collective action of farmers, as well as with more established transport, communication and education systems as development proceeds.

An empirical study by Honma and Hayami (1986) makes an attempt to identify both economic and political factors underlying agricultural protectionism accompanied by economic growth and industrialization. Using a multiple regression method, they found that more than 70 percent of variation in the nominal rates of protection among ten industrial countries over the period of 1955-80 can be explained by three major factors: agricultural comparative advantage due to capital accumulation, agriculture's share in total economy and the international agricultural terms of trade. Balisacan and Roumasset (1987) develop a conceptual framework that embeds the public choice aspects of group provision of political influence to explain the growth of agricultural protection. The main focus primarily is on the direct determinants of the benefits and costs of investments by the proponents and opponents of agricultural protection and on how changes in the benefit-cost structure may lead to changes in agricultural policy. A simple regression analysis over the period of 1979-81 is tested for the relationship between agricultural protection and development. The weighted average of estimated nominal rates of protection (NRP) of major grains, used as an indicator of domestic policy distortions, is regressed on certain indicators of economic development. Their results show that capital-labor ratio, capital-land ratio and the proportion of income spent on food are positively related to nominal rates of protection.

Anderson and Tyers (1989) advance a number of hypotheses in explaining the observed agricultural protection patterns. They argue that in the case of a developing country there exists a weak demand for protection due to the small share of agricultural output marketed by subsistence farmers and the likely absence of agricultural lobbying groups. The potential costs to governments of reduced political support from non-agricultural sectors due to providing agricultural protection to farmers, would be high in developing countries with large agricultural populations. A policy shift away from agricultural taxation also reduces tax revenues and, more importantly, hinders the promotion of industrialization in view of its impact on foreign earnings, protection of import-

competing manufactures and wages on urban sector. The situation, however, is reversed once a country is industrializing. In addition to a decrease in free-rider problems among farmers' groups, the opposition to agricultural protection is also mitigated due to lower food expenditure shares in consumers' budgets and to lower wage share in industrial production costs as capital accumulates in the process of economic development. Fulginiti and Shogren (1992) use the theory of collective action (Olson, 1982) and the economic theory of a rent-seeking contest (Tullock, 1980) between agricultural and industrial sectors to explain agricultural protectionism. Rent-seeking efforts are made by two sectors to compete for the rent (i.e., a direct subsidy), depending upon relative strength of the sector, the level of rent, the sector's sharing rule, and political environment. The regulator makes optimal policy choice by maximizing his expected utility as a function of rent-seeking efforts from two sectors. As an economy develops, the sector supported may change as factors affecting rent-seeking efforts change with economic growth. Using World Bank data on direct and indirect interventions on agriculture of eighteen developing countries from 1960 to 1984, Fulginiti and Shogren (1992) regress nominal protection coefficients of major agricultural products in each country on major factors underlying rent-seeking efforts. Their results show the coefficient of agriculture's share is not significant; land per capita and labor productivity ratio have expected negative signs and are significant, suggesting countries with comparative advantage in agriculture are more likely to tax agriculture to generate public revenue; agriculture's export share shows a negative sign and is significant, indicating agricultural commodities with greater shares in exports are more likely to be taxed; both exportables and importables dummies are significant and show that importables are relatively protected; the coefficients of indirect protection variables are significant and indicate that direct agricultural protection tends to increase with lower real exchange rate and stronger industrial protection; food dummy shows insignificant, indicating same tax treatment for food and nonfood products; and the coefficient of income per capita shows positive sign and is significant, suggesting rich countries are more likely to protect agriculture.

ii) The Voting Model

The works by de Gorter and Tsur (1991) and Swinnen (1994) take a different approach that stresses the role of politicians in the formulation of agricultural policies. They argue that the observed 'numbers paradox' is only part of what happens during the shift of agricultural policy in a growing economy. Their models are based on the interaction between political support-maximizing politicians and political support-supplying voters.

De Gorter and Tsur (1991) formulate a theoretical model focusing on the income differential between farmers and non-farmers as a major determinant of price policy bias in agriculture. Their political economic model assumes that individuals are concerned with their income relative to those in opposing sector and with the effect of government policies on their own income, both in turn affecting supply of political support and hence endogenously determining the redistributive policy. Using data from Krueger et al. (1988), the validity of their model is tested and supported with a regression analysis where the nominal rates of protection, used as a proxy for the level of transfers between the rural and urban sector, are regressed on endowment income differentials, the ratio of urban to rural population, a binary variable capturing net trade influence, a binary variable indicating rice crop, per capita arable land, and a variable indicating the development stage of the country. Since the income gap is affected by the NRP, i.e., two variables are jointly determined, an instrumental variable is used for the actual income gap variable. The instrumental variable is a predicted value of income gap from a regression estimation that regresses actual income gap on variables used in the original equation plus rural and urban population, average per capita income, and binary variables for wheat and corn. Their results show a significantly positive relationship between rural-urban income differentials and levels of agricultural protection.

Swinnen (1994) generalizes the approach of de Gorter and Tsur (1991) to analyze the impact of structural changes accompanied by economic development on the level of agricultural protection. The impact of agricultural-nonagricultural income differentials (caused by relative productivity

ratios) on agricultural protection is determined in a political market where rational politicians offer redistributive policies to maximize political support from citizens with different factor endowments. Such a theoretical model integrates the political economic model with a general equilibrium specification of the economy. Based on a specific factor model due to the inherent short-run nature of the political process (Baldwin, 1984; and Magee et al., 1989), Swinnen shows that the political equilibrium policy is endogenously determined by factors reflecting relative welfare levels and structural changes in the process of economic development, including the urban-rural income gap, capital intensity, the share of agriculture in total output and total employment, and the food expenditures share in consumer's budgets. The endogenous nature of agricultural policy determination in a growing economy thus implies that factors associated with structural changes that determine political weights (power) change as well when income is redistributed.

Theoretical Analysis

To analyze the mechanisms through which the demand and supply-side factors affect the relative size of the agricultural sector in an open economy under economic growth, we develop a theoretical framework, building in part on the specific-factors model of trade (Jones, 1971). Land is incorporated in the model as a third factor of production in addition to labor and capital. This recognizes a distinguishing feature of the agricultural sector being substantially land-based, as compared to non-agricultural production. The analysis proceeds by deriving the comparative statics properties of the model.

To explain the development of the agricultural sector in the process of the structural transformation of a growing *open* economy, various hypotheses have been advanced. The demand explanations based on Engel's Law, which is crucial in the case of a closed/global economy,² becomes less important as domestic production is not required to equal domestic demand in equilibrium when an economy is open to international trade. An economy under conditions of comparative advantage in agricultural production, such as being endowed with abundant land resource, can specialize in agricultural production and trade. On the supply side, as an economy develops and capital is accumulated, its factor endowment is altered and so is its comparative advantage, leading to changes in an economy's production structure. Moreover, the rates of productivity growth between agricultural and nonagricultural sectors tend to differ with economic growth, thereby resulting in differential output growth rates between sectors. Furthermore, the agricultural sector-specific and macroeconomic and trade policies play important roles in affecting agricultural incentives and hence agricultural growth in the process of economic growth. In what follow we examine those factors respectively.

Theoretical Model

The specific-factors model considers a small open economy which consists of two sectors--agriculture (a) and nonagriculture or the rest of the economy (n). The agricultural sector employs labor and land while the nonagricultural sector employs labor and capital.³ Land is specific to the agricultural sector and capital is specific to the nonagricultural sector. The specific factors are in fixed supply and immobile between sectors. Only one factor, labor, is freely mobile between the two sectors. All factors exhibit diminishing marginal product in each sector. Both sectors have

² Nerlove (1996) analyzes the tendency of agriculture's relative decline during the process of economic growth in a *closed* or *global* economy using a simple framework for the sectoral shifts in demand with rising real per capita income and growing population.

³ In reality, agricultural production requires also capital. One way to make realistic the assumption that agricultural production requires only land and labor in the original specific-factors model is to consider the factor 'land' as representing a variety of factors that are specific to agriculture, including agricultural capital. In a longer run, one needs to consider capital also mobile between sectors. We modify the original model by considering explicitly capital as another factor of production in agriculture and get similar qualitative results. The analysis is omitted due to space limitation.

strictly concave production functions which are homogeneous of degree one in inputs, i.e., exhibiting constant return to scale, and have continuous second-order partial derivatives. Output prices are given by the world market. Production functions for each of the two goods are:

- (1) $Y_a = F(L_a, H) = L_a \cdot F(1, H/L_a) = L_a \cdot f(h_a)$,
 $f(0) = 0, f(\infty) = \infty, f' > 0, f'' < 0, f'(0) = \infty, f'(\infty) = 0$; and
(2) $Y_n = G(L_n, K) = L_n \cdot G(1, K/L_n) = L_n \cdot g(k_n)$,
 $g(0) = 0, g(\infty) = \infty, g' > 0, g'' < 0, g'(0) = \infty, g'(\infty) = 0$;

where Y_a and Y_n are agricultural and nonagricultural outputs; H and K , the fixed supplies (endowments) of the specific inputs, land and capital, respectively; and L_a and L_n , the labor allocated to each sector; h_a is the land-labor ratio (or per worker endowment of land) in the agricultural sector; and k_n is the capital-labor ratio (or per worker endowment of capital) in the nonagricultural sector. Also, L_a and L_n sum to the total fixed labor, L , i.e.,

(3) $L_a + L_n = L$.

Given perfect competition in both product and factor markets, the rental on labor will be equated in the two sectors and equal to its value of marginal product, ω . Hence, we have

(4-5) $P_a \cdot \partial Y_a / \partial L_a = P_n \cdot \partial Y_n / \partial L_n = \omega$,

which determines the equilibrium allocation of L_a^* and L_n^* , and the wage rate ω^* .⁴ Thus, at a given set of international prices, the wage rate is determined by the overall per worker endowment of land and per worker endowment of capital, with labor being allocated between the two sectors according to the ratio of land to capital in an economy. Given the equilibrium wage rate, ω^* , zero-profit conditions allow us to determine the rental rates on sector-specific factors, γ and π , which are equal to the value of marginal products of capital and land, respectively, evaluated at the equilibrium values of L_a^* and L_n^* as follows:

(6) $\gamma = P_n \cdot \partial Y_n / \partial K$, and

(7) $\pi = P_a \cdot \partial Y_a / \partial H$.

Here, there are seven equations in seven endogenous variables: $Y_a, Y_n, L_a, L_n, \omega, \pi, \gamma$ and thus the small-economy model is exactly determined. Five exogenous variables are P_a, P_n, L, H , and K .

By solving equations (1) through (7) we obtain the locus of efficient outputs for the economy, i.e., the production possibility frontier (PPF), specified as $\phi(Y_a, Y_n, H, K, L, \Omega) = 0$, corresponding to the society's resource availability (H, K , and L) and aggregate technology level, Ω . The supply side of the economy is characterized by the production possibility frontier. Introduction of the land endowment ensures that agricultural production functions, and hence production possibility frontiers differ across economies according to their land resource endowment, hence explaining some of the cross-economy variations in production possibilities.⁵

Given the assumption of competitive product and factor markets, the optimizing allocation of outputs between sectors leads to maximization of the total value of output subject to the PPF, given the commodity prices, P_a and P_n ; the economy's total factor endowments, H, K , and L ; and the aggregate technological level, Ω . In the absence of any taxes, subsidies or associated transfers, the revenue function $R(\cdot)$ is defined as

(8) $R(P_a, P_n, H, K, L, \Omega) \equiv \max_{Y_a, Y_n} \{P_a Y_a + P_n Y_n : \phi(Y_a, Y_n, H, K, L, \Omega) \leq 0\}$.

⁴ Unlike in the standard Heckscher-Ohlin model, the solution for factor prices in specific-factors model can no longer be obtained exclusively in terms of goods prices and has to be dependent on factor endowments because of the existence of sector-specific factors of production.

⁵ Although the specific-factors model is usually regarded as a short-run version of the 2×2 Heckscher-Ohlin model by viewing sector-specific factors as sector-one and sector-two capitals that are intersectorally immobile in the short run, but perfectly mobile in the long run (Neary, 1978a, 1978b), it may not necessarily be the case when specific factors dealt with in the analysis are land and capital, which differs substantially in nature with limited possibility of input substitution.

Condition (8) states that the revenue function of an economy with given factor endowments and facing given commodity prices is the maximum value of outputs by choosing the optimal feasible resource allocation. The revenue function or the gross domestic product (GDP) function, is an important component of the dual approach and is useful in analyzing resource allocation and production in an economy. The equilibrium aggregate supplies of goods and the market factor prices can be obtained by differentiating the revenue function, assuming differentiability, whereas with the traditional, primal approach which emphasizes production functions of the sectors it requires solving a system of equations, i.e. eqs. (1)-(7) to obtain the values of these same variables. In specific, $\partial R / \partial P_i = Y_i$, $i = a, n$; $\partial R / \partial L = \omega$; $\partial R / \partial K = \gamma$; and $\partial R / \partial H = \pi$.⁶

i. Land Resource Endowment and Agricultural Trade

Consider the derivation of comparative static property of a change in land resource endowment in the specific-factors model. Holding commodity prices constant, the effect of an increase in land resource endowment will clearly increase the marginal productivity of labor in the agricultural sector, hence drawing labor toward the agricultural sector and away from the other. As a result, an increase in the endowment of land resource leads to an increase in the output of the agricultural sector and a decline in the output of the nonagricultural sector.

Thus, we have

$$(9) \quad \begin{aligned} &\text{i. } \partial^2 R / \partial H \partial P_a = \partial Y_a / \partial H = \partial \pi / \partial P_a > 0 ; \text{ and} \\ &\text{ii. } \partial^2 R / \partial H \partial P_n = \partial Y_n / \partial H = \partial \pi / \partial P_n < 0. \end{aligned}$$

Making use of these comparative statics properties of a change in land resource endowment, and allowing the relative commodity price, P_a/P_n to adjust to clear the commodity markets, we can compare the autarky price ratios of differently endowed economies and so determine the patterns of comparative advantage and trade predicted by the model.

ii. Capital Accumulation and Changing Comparative Advantage

In the early stages of development, an economy's comparative advantage is primarily determined by its endowment of land, unskilled labor, and traditional technologies. As an economy develops, its income grows and capital is accumulated,⁷ thereby altering this economy's factor endowment and hence its comparative advantage.⁸ Labor will be attracted to the nonagricultural sector in which capital is sector-specific input, thus resulting in expanding the supply of nonagricultural output and contracting that of the agricultural sector. As an increase in capital increases the nonagricultural sector's marginal product of labor, the equilibrium labor allocation shows a diversion of labor away from the agricultural sector to the nonagricultural sector, leading to a reduction in agricultural output and an increase in nonagricultural output, very much *a la Rybczynski effect* in the standard Heckscher-Ohlin trade model. We have

$$(10) \quad \begin{aligned} &\text{i. } \partial^2 R / \partial K \partial P_a = \partial Y_a / \partial K = \partial \gamma / \partial P_a < 0 ; \\ &\text{ii. } \partial^2 R / \partial K \partial P_n = \partial Y_n / \partial K = \partial \gamma / \partial P_n > 0 . \end{aligned}$$

iii. Differential Rates of Technological Change between Sectors

To analyze the effects of differential sectoral rates of technological change on sectoral output shares, the specific-factors model is amended to incorporate technological change at different rates in the two sectors, drawing in part on the works of Jones (1965) and Neary (1981). The augmented model is summarized in equations (11)-(19) which represent all the equilibrium relationships for a competitive economy with given commodity prices and fixed factor endowments.

⁶ Other properties of the revenue function include: being linearly homogeneous in output prices; convex in output prices, non-negative, non-decreasing in endowments, and non-decreasing in output prices.

⁷ Economic growth can also result from population growth and productivity growth. An analysis of the effect of population growth on sectoral shares is not pursued here, while it is clear that an increase in labor force will increase the outputs of both goods in proportion to each sector's elasticity of labor demand. The effect of productivity growth is analyzed in the next section.

⁸ An economy can also alter its comparative advantage in a *dynamic* setting through investment in research and development, education, infrastructure, and technology.

- (11) $C^a(\omega, \pi, t_a) = P_a$, or (151) $\phi_{La}\omega + \phi_{Ha}\pi = P_a$;
 (12) $C^n(\omega, \gamma, t_n) = P_n$, or (161) $\phi_{Ln}\omega + \phi_{Kn}\gamma = P_n$;
 (13) $\phi_{La}(\omega, \pi, t_a) = C_{\omega}^a(\omega, \pi, t_a)$,
 (14) $\phi_{Ha}(\omega, \pi, t_a) = C_{\pi}^a(\omega, \pi, t_a)$,
 (15) $\phi_{Ln}(\omega, \gamma, t_n) = C_{\omega}^n(\omega, \gamma, t_n)$,
 (16) $\phi_{Kn}(\omega, \gamma, t_n) = C_{\gamma}^n(\omega, \gamma, t_n)$,
 (17) $\phi_{La}Y_a + \phi_{Ln}Y_n = L$,⁹
 (18) $\phi_{Ha}Y_a = H$,
 (19) $\phi_{Kn}Y_n = K$,

where $C^j(\cdot)$ is the unit-cost function, $j = a, n$; $\phi_{Lj} (\equiv L_j/Y_j)$, labor-output ratio or unit input requirement in each sector, $j = a, n$; $\phi_{Ha} (\equiv H/Y_a)$, land-output ratio in the agricultural sector; $\phi_{Kn} (\equiv K/Y_n)$, capital-output ratio in the nonagricultural sector; and t_a and t_n , the technology parameters in the agricultural and nonagricultural sector, respectively. Eqs. (11) and (12) are the average-cost pricing conditions resulting from free entry. Alternatively, the conditions can be represented by eqs. (11-1) and (12-1), which state the competitive profit relationships. Eqs. (13)-(16) are the envelope properties of the unit-cost function given minimization behavior, known as the Shephard's Lemma; and eqs. (17)-(19) are full employment conditions. There are 9 equations in 9 endogenous variables: $Y_a, Y_n, \omega, \pi, \gamma, \phi_{La}, \phi_{Ha}, \phi_{Ln}, \phi_{Kn}$ and 7 exogenous variables are P_a, P_n, L, H, K, t_a , and t_n .

Technological progress is classified with reference to its effects on unit input requirements at constant relative factor prices. The assumptions of cost minimization and constant returns to scale ensure that each unit input requirement ϕ_{ij} , denoted as the quantity of factor i required to produce one unit of commodity j , to be written as a function of factor prices and of a technology parameter: $\phi_{La}(\omega, \pi, t_a)$, $\phi_{Ha}(\omega, \pi, t_a)$, $\phi_{Ln}(\omega, \gamma, t_n)$, and $\phi_{Kn}(\omega, \gamma, t_n)$. Since these unit input requirements are partial derivatives of the unit cost function, they are homogeneous of degree zero in factor prices. By totally differentiating eq. (13), we have

$$(20) \quad \hat{\phi}_{La} = [\theta_{Ha}] [\sigma^a] [(-1)\hat{\omega} + \hat{\pi}] - \lambda_{La},$$

where a hat (circumflex) over a variable indicates a proportional rate of change; θ_{Ha} is the income (or cost) share of land input in the agricultural sector (hence, $\theta_{Ha} + \theta_{La} = 1$); σ^a is the elasticity of substitution between labor and land in agricultural production; and λ_{La} is the proportionate *reduction* in $\phi_{La} (\equiv L_a/Y_a)$ due to technological progress at constant factor prices. Similarly, we have

$$(21) \quad \hat{\phi}_{Ha} = (-1)[\theta_{La}] [\sigma^a] [(-1)\hat{\omega} + \hat{\pi}] - \lambda_{Ha}.$$

Since $\phi_{La} = L_a/Y_a$ by definition, by taking logs and totally differentiating both sides, we obtain

$$(22) \quad \hat{\phi}_{La} = \hat{L}_a - \hat{Y}_a \text{ or } (22-1) \hat{Y}_a = \hat{L}_a - \hat{\phi}_{La}.$$

Similarly, we have

$$(23) \quad \hat{\phi}_{Ha} = \hat{H} - \hat{Y}_a \text{ or } (23-1) \hat{Y}_a = \hat{H} - \hat{\phi}_{Ha}.$$

Subtracting eq. (22) from eq. (23) yields

$$(24) \quad \hat{\phi}_{Ha} - \hat{\phi}_{La} = \hat{H} - \hat{L}_a.$$

Subtracting eq. (20) from eq. (21), together with eq. (24), we obtain

$$(25) \quad \hat{H} - \hat{L}_a = \hat{\phi}_{Ha} - \hat{\phi}_{La} = \sigma^a (\hat{\omega} - \hat{\pi}) + \Delta_{LHa},$$

where $\Delta_{LHa} (\equiv \lambda_{La} - \lambda_{Ha})$ is the Hicksian index of the bias of technological progress, measuring the proportionate change in the land-labor ratio attributable to technological change at constant factor

⁹ With constant returns to scale, total factor demand is the product of the ϕ and the level of output.

prices. Technological progress is labor-saving when Δ_{LHa} is positive and land-saving when Δ_{LHa} is negative, and Hicksian neutral when $\Delta_{LHa} = 0$. Similarly, we can derive

$$(26) \quad \hat{K} - \hat{L}_n = \hat{\phi}_{Kn} - \hat{\phi}_{Ln} = \sigma^n (\hat{\omega} - \hat{\gamma}) + \Delta_{LK_n}.$$

By multiplying eq. (22-1) by θ_{La} and multiplying eq. (23-1) by θ_{Ha} and combining both, together with the use of eq. (20) and eq. (21), we obtain

$$(27) \quad \theta_{La} \hat{Y}_a + \theta_{Ha} \hat{Y}_n = \theta_{La} \hat{L}_a + \theta_{Ha} \hat{H} + \Sigma_{LHa},$$

where $\Sigma_{LHa} (\equiv \theta_{La} \lambda_{La} + \theta_{Ha} \lambda_{Ha})$ is the Hicksian measure of the extent of technological progress in the agricultural sector, which gives the proportionate change in output when inputs are held constant. Similarly, we can derive

$$(28) \quad \hat{Y}_n = \theta_{Ln} \hat{L}_n + \theta_{Kn} \hat{K} + \Sigma_{LK_n}.$$

By subtracting eq. (27) from eq. (28), we obtain the difference of the proportionate changes between nonagricultural and agricultural outputs:

$$(29) \quad \hat{Y}_n - \hat{Y}_a = \theta_{Ln} \hat{L}_n + \theta_{Kn} \hat{K} + \Sigma_{LK_n} - (\theta_{La} \hat{L}_a + \theta_{Ha} \hat{H} + \Sigma_{LHa}).$$

The comparative statics effects of technological progress on sectoral output share are

examined in the following cases:

Case 1: Identical, output- and input-neutral technological progress in both sectors

Here, $\Sigma_{LHa} = \Sigma_{LK_n} \neq 0$, and $\Delta_{LHa} = 0$, and $\Delta_{LK_n} = 0$. Hence, there occurs the same proportionate changes in both agricultural and nonagricultural outputs, holding proportionate changes in factors of production constant.

Case 2: Input-neutral technological progress in each sector, but output-biased technological progress with rate of technological progress higher in the nonagricultural sector than the agricultural sector¹⁰

Here, $\Delta_{LHa} = 0$, and $\Delta_{LK_n} = 0$; and $\Sigma_{LK_n} > \Sigma_{LHa}$. In the case that farm production technologies improve more slowly than manufacturing technologies, an economy's comparative advantage in agriculture will decline. Therefore, the proportionate change in nonagricultural output is higher than that in agricultural output, holding proportionate changes in factors of production constant.

iv. Agricultural, Macroeconomic, and Trade Policies

a. Agricultural Investment Policies

Government spending in agricultural infrastructure (e.g. irrigation, electrification and transport), research and development, education, and extension services, etc., will increase agricultural productivity and in turn reduce the (labor) productivity gap between agricultural and nonagricultural sectors. Hence, governments can contribute to its agricultural growth with supportive agricultural investment policies.

b. Agricultural Pricing and Trade Policies

Agricultural pricing and trade policies have often shifted from discriminating against agriculture to supporting agriculture as an economy develops. In a political economic perspective, one may analyze the endogeneity of agricultural policies that tend to have a bias in favor of agriculture in response to the structural changes associated with economic growth. Swinnen (1994) provides a political economy model of agricultural protection in a general equilibrium framework

¹⁰ In general, however, technological change in agriculture or nonagriculture is an endogenous process induced primarily by changes in relative resource endowments and the growth of demand as an economy develops. According to Hayami and Ruttan (1985), agricultural research in different countries appears to exhibit a scarce factor-saving bias. That is, technological innovations respond to market incentives based on relative factor endowments, leading to input-biased technological progress.

and derives that i) agricultural protection will increase if agricultural income falls relative to income outside agriculture; ii) a decrease in agricultural employment will increase agricultural protection; iii) the political equilibrium subsidy will increase as the share of agriculture in total output declines; iv) in a small open economy, the politically optimal subsidy increases as the share of food expenditures decreases; and v) agricultural protection will increase with a decline in the degree of food self-sufficiency.

c. Macroeconomic Policies and Industrial Protection

Government intervention can indirectly affect the prices of agricultural tradables relative to nontradables through macroeconomic policies and those relative to other tradables through industrial protection, hence affecting production incentives in agriculture. The impact of such policies on incentives for agriculture can be evaluated through change in the real exchange rate (RER). The determinants of the real exchange rate, including changes in industrial protection, international capital flows, wages (the principal determinants of changes in the prices of home goods) and nominal exchange rates, can reinforce or neutralize aforementioned agricultural sector-specific policies. Autonomous factors such as the discovery of natural resources, or a change in international terms of trade for agricultural commodities, also affect the determination of the real exchange rate.

Simulation Analysis

Consider a small open developed economy with two tradable sectors: agriculture (a) and nonagriculture (n), where the agricultural sector is the import-competing sector which is supported with domestic farm programs and under tariff and non-tariff trade protection; and the nonagricultural sector is the export sector.¹¹ Since both goods are tradables in world markets, domestic prices are given by exogenous border (world) prices, corrected by relevant agricultural protection. Denote the domestic agricultural and nonagricultural price by P_a and P_n in domestic currency and world prices by P_a^* and P_n^* in foreign currency; the exchange rate by Er ; and the tariff-equivalent of all forms of protection or assistance applied to the agricultural sector by τ .¹² Thus, $P_a = P_a^* \cdot Er \cdot (1 + \tau)$. For simplicity of the analysis, assume the nonagricultural sector is free of policy distortions. Hence, $P_n = Er \cdot P_n^*$. The definition of the symbols used in the simulation model is summarized in Table 1.

Simulation Model

Given world prices, equilibrium in a simple two-sector general equilibrium model for a small open agricultural-importing economy is described by three parts: production (output), consumption, and trade balance.

A. Output:

- (s.1) $C^a(\omega, \gamma, \pi, t_a) = P_a$, or $\phi_{La}\omega + \phi_{Ka}\gamma + \phi_{Ha}\pi = P_a$,
- (s.2) $C^n(\omega, \gamma, t_n) = P_n$, or $\phi_{Ln}\omega + \phi_{Kn}\gamma = P_n$,
- (s.3) $\phi_{La}(\omega, \gamma, \pi, t_a) = C_\omega^a(\omega, \gamma, \pi, t_a)$,
- (s.4) $\phi_{Ka}(\omega, \gamma, \pi, t_a) = C_\gamma^a(\omega, \gamma, \pi, t_a)$,
- (s.5) $\phi_{Ha}(\omega, \gamma, \pi, t_a) = C_\pi^a(\omega, \gamma, \pi, t_a)$,
- (s.6) $\phi_{Ln}(\omega, \gamma, t_n) = C_\omega^n(\omega, \gamma, t_n)$,
- (s.7) $\phi_{Kn}(\omega, \gamma, t_n) = C_\gamma^n(\omega, \gamma, t_n)$,
- (s.8) $\phi_{La}Y_a + \phi_{Ln}Y_n = L$,
- (s.9) $\phi_{Ka}Y_a + \phi_{Kn}Y_n = K$, and

¹¹ The Model developed draws partly on the work by Anderson and Warr (1987).

¹² To complete the general equilibrium specification, assume that government budget constraint is met when domestic farm programs and trade measures for agricultural protection are implemented by government activities in non-distorting transfer payments as needed to make budget balanced.

$$(s.10) \quad \phi_{Ha} Y_a = H.$$

*The Equations of Change*¹³

To simulate the comparative-static effects of agricultural and trade policies on agriculture's relative size, we first totally differentiate eqs. (s.1)-(s.10) and convert them to get the equations of change:

$$(s.11) \quad \theta_{La} \hat{\omega} + \theta_{Ka} \hat{\gamma} + \theta_{Ha} \hat{\pi} + (\theta_{La} \lambda_{La} + \theta_{Ka} \lambda_{Ka} + \theta_{Ha} \lambda_{Ha}) = \hat{P}_a,$$

$$(s.12) \quad \theta_{Ln} \hat{\omega} + \theta_{Kn} \hat{\gamma} + (\theta_{Ln} \lambda_{Ln} + \theta_{Kn} \lambda_{Kn}) = \hat{P}_n,$$

$$(s.13) \quad \hat{\phi}_{La} = \theta_{La} \sigma_{LL}^a \hat{\omega} + \theta_{Ka} \sigma_{KL}^a \hat{\gamma} + \theta_{Ha} \sigma_{HL}^a \hat{\pi} - \lambda_{La},$$

$$(s.14) \quad \hat{\phi}_{Ka} = \theta_{La} \sigma_{LK}^a \hat{\omega} + \theta_{Ka} \sigma_{KK}^a \hat{\gamma} + \theta_{Ha} \sigma_{HK}^a \hat{\pi} - \lambda_{Ka},$$

$$(s.15) \quad \hat{\phi}_{Ha} = \theta_{La} \sigma_{LH}^a \hat{\omega} + \theta_{Ka} \sigma_{KH}^a \hat{\gamma} + \theta_{Ha} \sigma_{HH}^a \hat{\pi} - \lambda_{Ha},$$

$$(s.16) \quad \hat{\phi}_{Ln} = -\theta_{Kn} \sigma^n (\hat{\omega} - \hat{\gamma}) - \lambda_{Ln},$$

$$(s.17) \quad \hat{\phi}_{Kn} = \theta_{Ln} \sigma^n (\hat{\omega} - \hat{\gamma}) - \lambda_{Kn},$$

$$(s.18) \quad \alpha_{La} \hat{Y}_a + \alpha_{Ln} \hat{Y}_n = \hat{L} - (\alpha_{La} \hat{\phi}_{La} + \alpha_{Ln} \hat{\phi}_{Ln}),$$

$$(s.19) \quad \alpha_{Ka} \hat{Y}_a + \alpha_{Kn} \hat{Y}_n = \hat{K} - (\alpha_{Ka} \hat{\phi}_{Ka} + \alpha_{Kn} \hat{\phi}_{Kn}), \text{ and}$$

$$(s.20) \quad \hat{Y}_a = \hat{H} - \hat{\phi}_{Ha}.$$

B. Consumption

The demand for agricultural and nonagricultural goods are given by $C_a = C_a(P_a, P_n, Y)$, and $C_n = C_n(P_a, P_n, Y)$, respectively, where Y denotes the national income.¹⁴ By totally differentiating C_a , and C_n , we obtain

$$(s.21) \quad dC_a = \frac{\partial C_a}{\partial P_a} dP_a + \frac{\partial C_a}{\partial P_n} dP_n + \frac{\partial C_a}{\partial Y} dY, \text{ and}$$

$$(s.22) \quad dC_n = \frac{\partial C_n}{\partial P_a} dP_a + \frac{\partial C_n}{\partial P_n} dP_n + \frac{\partial C_n}{\partial Y} dY.$$

National income, Y , is composed of agricultural and nonagricultural income:

$$(s.23) \quad Y = P_a Y_a + P_n Y_n.$$

It follows from totally differentiating eq. (s.23) that

$$(s.24) \quad dY = Y_a \cdot dP_a + P_a \cdot dY_a + Y_n \cdot dP_n + P_n \cdot dY_n.$$

Substituting eq. (s.24) into eq. (s.21) yields

$$(s.25) \quad dC_a = \left[\frac{\partial C_a}{\partial P_a} \right]_{\bar{U}} dP_a + \left[\frac{\partial C_a}{\partial P_n} \right]_{\bar{U}} dP_n + \frac{\partial C_a}{\partial Y} \cdot (P_a \cdot dY_a) + \frac{\partial C_a}{\partial Y} \cdot (P_n \cdot dY_n),$$

where the first and second bracketed terms denote income-compensated (i.e., utility is held constant) own-price and cross-price (substitution) effects on agricultural demand, respectively; while the third and fourth terms denote income effects on agricultural demand due to changes in agricultural and

¹³ A hat (circumflex) over a variable indicates a proportional rate of change.

¹⁴ To simplify the analysis, assume identical income and consumption preference for all consumers.

nonagricultural income, respectively. Note that Y_a and Y_n denote the *quantities* of agricultural and nonagricultural output, respectively.

Similarly, we have

$$(s.26) \quad dC_n = \left[\frac{\partial C_n}{\partial P_a} \right]_{\bar{U}} dP_a + \left[\frac{\partial C_n}{\partial P_n} \right]_{\bar{U}} dP_n + \frac{\partial C_n}{\partial Y} \cdot (P_a \cdot dY_a) + \frac{\partial C_n}{\partial Y} \cdot (P_n \cdot dY_n).$$

Eq. (s.25), when converted into proportional change form, becomes

$$(s.27) \quad \hat{C}_a = \xi_{aa} \cdot \hat{P}_a + \xi_{an} \cdot \hat{P}_n + \eta_{aY} \cdot (\hat{Y}_a + \hat{Y}_n),$$

where ξ_{aa} and ξ_{an} are the income-compensated price elasticities of demand for agricultural goods with respect to agricultural and nonagricultural prices, respectively; and η_{aY} is the income elasticity of demand for agricultural goods. In a similar fashion, we derive

$$(s.28) \quad \hat{C}_n = \xi_{na} \cdot \hat{P}_a + \xi_{nn} \cdot \hat{P}_n + \eta_{nY} \cdot (\hat{Y}_a + \hat{Y}_n),$$

where ξ_{na} and ξ_{nn} are the income-compensated price elasticities of demand for nonagricultural goods with respect to agricultural and nonagricultural prices, respectively; and η_{nY} is the income elasticity of demand for nonagricultural goods.

C. Trade

By assumption that the economy imports agricultural products (M_a) and exports

nonagricultural goods (X_n), we have

$$(s.29) \quad C_a - Y_a = M_a > 0, \quad \text{and}$$

$$(s.30) \quad Y_n - C_n = X_n > 0.$$

The balance of trade is attained when total demand is equal to total revenue in the economy, that is,

$$P_a C_a + P_n C_n = P_a Y_a + P_n Y_n,$$

$$P_a (C_a - Y_a) = P_n (Y_n - C_n),$$

$$(s.31) \quad P_a \cdot M_a = P_n \cdot X_n.$$

Totally differentiating eq. (s.29) yields

$$(s.32) \quad \hat{M}_a = \frac{1}{1 - \delta_a} \hat{C}_a - \frac{\delta_a}{1 - \delta_a} \hat{Y}_a,$$

where $\delta_a (\equiv Y_a/C_a)$ is the self-sufficiency ratio for the agricultural sector. Hence, $(1 - \delta_a) = (C_a - Y_a)/C_a = M_a/C_a$. Similarly, we have

$$(s.33) \quad \hat{X}_n = (\hat{Y}_n \cdot \delta_n - \hat{C}_n) / (\delta_n - 1),$$

where $\delta_n (\equiv Y_n/C_n)$ is the self-sufficiency ratio for the nonagricultural sector. Note that by assumption it follows that $\delta_n > 1 > \delta_a > 0$.

It should be noted that agricultural import (nonagricultural export) is the net value of agricultural consumption and production (nonagricultural production and consumption). Trade balance is automatically attained once domestic demand for and supply of both goods are determined by solving the system.

System of Equations

To examine the effects of changes in agricultural price and other exogenous variables, we have derived the equilibrium conditions in proportional change form, including eqs. (s.11)-(s.20), (s.27) and (s.28). These twelve equations can be reduced to seven equations by substituting eqs. (s.13)-(s.17) into eqs. (s.18)-(s.20), which become (s.18)' - (s.20)':

$$(s.18)' \quad \alpha_{La} \hat{Y}_a + \alpha_{Ln} \hat{Y}_n = \hat{L} - \alpha_{La} [\theta_{La} \sigma_{LL}^a \hat{\omega} + \theta_{Ka} \sigma_{KL}^a \hat{\gamma} + \theta_{Ha} \sigma_{HL}^a \hat{\pi} - \lambda_{La}] \\ - \alpha_{Ln} [-\theta_{Kn} \sigma_{Ln}^n (\hat{\omega} - \hat{\gamma}) - \lambda_{Ln}],$$

$$(s.19)' \quad \alpha_{Ka} \hat{Y}_a + \alpha_{Kn} \hat{Y}_n = \hat{K} - \alpha_{Ka} [\theta_{La} \sigma_{LK}^a \hat{\omega} + \theta_{Ka} \sigma_{KK}^a \hat{\gamma} + \theta_{Ha} \sigma_{HK}^a \hat{\pi} \\ - \lambda_{Ka}] - \alpha_{Kn} [\theta_{Ln} \sigma_{Ln}^n (\hat{\omega} - \hat{\gamma}) - \lambda_{Kn}], \text{ and}$$

$$(s.20)' \quad \hat{Y}_a = \hat{H} - [\theta_{La} \sigma_{LH}^a \hat{\omega} + \theta_{Ka} \sigma_{KH}^a \hat{\gamma} + \theta_{Ha} \sigma_{HH}^a \hat{\pi} - \lambda_{Ha}].$$

In summary, the model consists of seven equations (i.e., eqs. (s.11), (s.12), (s.18)', (s.19)', (s.20)', (s.27) and (s.28)) with seven endogenous variables ($\hat{\omega}$, $\hat{\gamma}$, $\hat{\pi}$, \hat{Y}_a , \hat{Y}_n , \hat{C}_a , \hat{C}_n) and ten exogenous variables (\hat{P}_a , \hat{P}_n , \hat{L} , \hat{K} , \hat{H} , λ_{La} , λ_{Ka} , λ_{Ha} , λ_{Ln} , λ_{Kn}).

Policy Simulations¹⁵

To simulate policy effects, a number of parameter values are required. The parameter values are assumed based on data from a number of sources as given in Table 2.¹⁶ The income or cost shares of inputs in two sectors (θ_{La} , θ_{Ka} , θ_{Ha} , θ_{Ln} , and θ_{Kn}) are assumed given data reported in the United Nations, *National Accounts statistics, 1980*.¹⁷ The cross partial elasticities of substitution in production between factors in each sector, $\sigma_{KL}^a (= \sigma_{LK}^a)$, $\sigma_{HL}^a (= \sigma_{LH}^a)$, $\sigma_{HK}^a (= \sigma_{KH}^a)$, and $\sigma_{Ln}^n (= \sigma_{nL}^n = \sigma_{nK}^n)$, are assumed to be 0.50, assuming a CES production function. The values for σ_{LL}^a , σ_{KK}^a , and σ_{HH}^a are derived, given that $\theta_{La} \sigma_{LL}^a + \theta_{Ka} \sigma_{LK}^a + \theta_{Ha} \sigma_{LH}^a = 0$, $\theta_{La} \sigma_{KL}^a + \theta_{Ka} \sigma_{KK}^a + \theta_{Ha} \sigma_{KH}^a = 0$, and $\theta_{La} \sigma_{HL}^a + \theta_{Ka} \sigma_{HK}^a + \theta_{Ha} \sigma_{HH}^a = 0$. The values of intersectoral distribution of labor (α_{La} and α_{Ln}) are based on data for Taiwan in 1980 from *Taiwan Statistical Data Book*.¹⁸ The income elasticity of demand for agricultural products (η_{ay}) has been found empirically to average about 0.5 (Houthakker, 1957),¹⁹ while it is generally lower in an economy with higher income per capita. Based on estimates of income elasticities of demand and budget shares reported in Lluch, Powell, and Williams (1977), we have the following assumed figures. The income elasticities of demand for agricultural products (η_{ay}) is assumed to be 0.30 and the values for the income elasticity of demand for nonagricultural goods (η_{ny}) to be 1.25. The budget shares (ϖ_i) of agricultural and nonagricultural consumption are assumed to be 0.20 and 0.80, respectively.

Given the estimates of the uncompensated own- and cross-price elasticities of demand for agricultural and nonagricultural products ($E_{ij} = \frac{P_j}{C_i} \cdot \frac{\partial C_i}{\partial P_j}$, $i, j = a, n$) reported in Lluch, Powell, and Williams (1977), the various income-compensated own- and cross-price elasticities (ξ_{ij}) are derived using the Euler equations (i.e., $\sum_j E_{ij} + \eta_{iy} = 0$, $i, j = a, n$) and the Slutsky equations (i.e., $E_{ij} = \xi_{ij}$

¹⁵ The simulation analysis for the case of a *less developed* economy is not presented in this paper due to space limitation.

¹⁶ Ideally, the parameter values based on statistics from one specific economy is preferred. In practice, however, there exists difficulty in finding those figures pertaining only to one specific economy.

¹⁷ The figures are computed based on data on cost components of value added.

¹⁸ Data on Taiwan as economy example are used for the case of a developed open economy in simulation.

¹⁹ Houthakker's analysis is based on a number of surveys on the international comparison of expenditure patterns on four major expenditure items (food, housing, clothing, and all other items), nearly all of which refer to urban households.

– $\varpi_j \eta_{iy}$ or $E_{ij} = \frac{\varpi_j}{\varpi_i} E_{ji} + \varpi_j (\eta_{iy} - \eta_{ij})$, for $i \neq j = a, n$). For the case of a developed economy, $E_{aa} = -0.22$, $E_{an} = -0.08$, $E_{na} = -0.21$, and $E_{nn} = -1.04$ are reported and the derived values for ξ_{aa} , ξ_{an} , ξ_{na} , and ξ_{nn} are -0.16 , 0.16 , 0.04 , and -0.04 , respectively.

To simulate the comparative-static effects of agricultural protection, a base case and four scenarios of simulation are run for each type of economy. The extent of agricultural protection is measured by a rate of change in agricultural price due to a change in the policy parameter, τ , i.e., the price-equivalent of all forms of protection or subsidization provided to the agricultural sector by government policies. Given initial values of the exogenous variables, the comparative-static effects on agriculture's relative share in total GDP of agricultural support policies can be calculated with simulated values of endogenous variables (in rates of percentage change).

To see how agriculture would have fared in free markets, a base case is assumed with initial values of percentage change in both agricultural and nonagricultural prices set to 10 percent. The initial values of rates of percentage change in labor, capital, land, neutral agricultural technological change (i.e., λ_{La} , λ_{Ka} , and λ_{Ha} increase at the same rate) and neutral nonagricultural technological change (i.e., λ_{Ln} and λ_{Kn} increase at the same rate) are 1.8, 10, 0, 8, 8, 8, 12, and 12 percent, respectively. The values of non-zeros (and positive) assumed for the rates of percentage change in factors of production and technological changes indicate an economy's economic growth, while the simulation considers no change in the stock of total land as it is more or less fixed in individual economy over time.

Four scenarios are considered in the simulation runs. Conditions simulated are:

Scenario 1: a 20% increase in agricultural price due to agricultural support policies;

Scenario 2: a 30% increase in agricultural price due to agricultural support policies;

Scenario 3: a 30% increase in agricultural price due to agricultural support policies and an increase in technological change in agriculture from 8% to 12 % on a par with that in nonagriculture;²⁰ and

Scenario 4: a 50% increase in agricultural price due to agricultural support policies.

Simulation Results

Table 3. shows the simulation results for agricultural-importing developed economy. The simulation result of the base case shows that agriculture's GDP share would decline to 6.88 percent (compared to the initial value of 7.68 percent before economic growth) in an agricultural-importing developed economy without agricultural policy support. The result of simulation scenario 1 shows that, with higher agricultural support agriculture's GDP share increases to 7.96 percent compared to 6.88 percent in the base case. The result of simulation scenario 2 shows also a higher agricultural protection level would result in a larger agriculture's GDP share (7.96 percent vs. 9.12 percent). In scenario 3, agricultural price is supported by 30-percent same as scenario 2, while agricultural productivity growth increases from 8% to 12 % on a par with that in nonagriculture. The simulation result shows agriculture's relative share increases to 9.18 percent from 9.12 percent in scenario 2. The result of scenario 4 shows again a higher agricultural protection level would lead to a larger agriculture's GDP share (11.72 percent vs. 9.18 percent). The simulation results show in all cases a reduction in agricultural policy support, i.e., agricultural trade liberalization would result in a lower relative share of agriculture in the total economy. The results of scenarios 2 and 3, however, indicate that a higher level of agricultural productivity would lead to a larger agricultural sector.

Sensitivity Analysis

To examine the robustness of the simulation results to changes in the parameter values, the sensitivity of the results to changes in the parameters has been examined. Eight sets of parameter values are used. The sensitivity analysis shows that the endogenous prices and quantities, and the

²⁰ This may result from government non-price agricultural support policies such as increased government expenditures on agricultural research and development which promotes agricultural productivity growth

rate of decline of agriculture's GDP share are robust to changes in the assumed values of the cost shares of factors of production, the elasticities of substitution between factors of production, the distributive shares of factors of production in both sectors, and price and income elasticities of demand for both agricultural and nonagricultural goods in agricultural-importing developed economy. In all the cases, varying the parameter values changes the rate of decline of agriculture's GDP share by less than two percentage points. The capability of support policies to offset the declining GDP share is also robust.²¹

Econometric Analysis

Econometric Model

For a given small open economy, a simultaneous equations model for investigating the preceding hypotheses may be written

$$(*1) \quad \text{AgGDP}\%_t = \alpha_0 + \alpha_1 \cdot \text{ANRAP}_t + \alpha_2 \cdot \text{RpcGDP}_t + \alpha_3 \cdot \text{AgResLg}_t + \alpha_4 \cdot \text{AgLandPC}_t + \alpha_5 \cdot \text{IATOT}_t + \varepsilon_{1t},^{22}$$

$$(*2) \quad \text{ANRAP}_t = \beta_0 + \beta_1 \cdot \text{AgGDP}\%_t + \beta_2 \cdot \text{LaborProdR}_t + \beta_3 \cdot \text{FtEndowR}_t + \beta_4 \cdot \text{SelfSfC}_t + \varepsilon_{2t},^{23}$$

where $\text{AgGDP}\%_t$ denotes agriculture's relative share in total GDP at time t ,²⁴

ANRAP_t denotes average nominal rate of agricultural protection at time t ,

RpcGDP_t denotes real per capita GDP at time t ,

AgResLg_t denotes 3-year lagged public agricultural research expenditures at time t ,²⁵

AgLandPC_t denotes agricultural land per capita at time t ,

IATOT_t denotes international agricultural terms of trade at time t ,

LaborProdR_t denotes labor productivity ratio, agriculture vs. nonagriculture, at time t ,

FtEndowR_t denotes factor-endowment (land-capital) ratio at time t ,

SelfSfC_t denotes 3-year lagged self-sufficiency rate in cereals at time t , and

ε_{1t} and ε_{2t} denote the classical disturbance terms in the first and second equations, respectively, such that ε_{jt} is i.i.d. $\sim N(0, \sigma^2)$, $j = 1, 2$.

The system is simultaneously determined for two endogenous variables: $\text{AgGDP}\%_t$, and ANRAP_t . In eq. (*1), real per capita GDP is included to account for the effects on agriculture's relative size of Engel's Law, differential rates of technological change between sectors, and the change in relative factor supplies; and average nominal rate of agricultural protection is included to measure the policy effect on production incentives to the agricultural sector. In eq. (*2), three variables associated with structural change in a growing economy: agriculture's relative size, and

²¹ Detailed figures of sensitivity test results are not shown due to space limitation. They are available from the author.

²² According to Syrquin and Chenery (1989), an economy's total population size, trade orientation, and the degree of openness all have a significant impact on the pattern of its structural change. Their study shows that at low income levels, large countries were more industrialized than small ones, while a high degree of convergence occurred at higher income levels, thus indicating a faster transformation in smaller countries. This provides the empirical ground for including population size as one explanatory variable in agriculture's relative share equation. The estimation results, however, show that when including population size, the coefficient of real per capita GDP becomes insignificant in most cases. As the variable of real per capita GDP is of importance for use in assessing the growth or income effect, we do not include the variable of population size in estimation.

²³ Labor productivity ratio and factor-endowment ratio may also be determined by agricultural protection level, while the results of the tests for exogeneity for both variables do not support the inclusion of both variables being treated as additional endogenous variables in the model.

²⁴ Agriculture's relative size is represented alternatively by agriculture's relative share in total labor force ($\text{AgLabor}\%$).

²⁵ We use three-year lagged data on public agricultural research expenditures as it requires time to realize research effort in yield and output. A longer-period lag should be preferred, while in so doing, a loss in data points would be resulted in.

the indicators of comparative advantage in agriculture, are included to account for variations in endogenously determined agricultural protection levels with economic growth.

Data

Data from various international organizations, mostly affiliated with the United Nations, are available for Japan, South Korea, Thailand, Malaysia, and Indonesia (hereafter referred to as JSTMI). Data for Taiwan come mainly from Taiwanese government sources.²⁶ The data set consists of 42 annual observations for Japan, South Korea, and Taiwan, for the period 1955-1996; and 31 annual observations for Thailand, Malaysia, and Indonesia, for the period 1966-1996.²⁷

Real Per Capita GDP

During the postwar period, Japan, South Korea, and Taiwan have grown rapidly, with average rates of growth more than double the world as a whole. Thailand, Malaysia, and Indonesia have also had unprecedentedly rapid economic growth in the past three decades. Despite high rates of economic growth in all six economies, the levels of real per capita GDP differ substantially among them, with Japan attaining an extremely high level and Indonesia at a considerably lower level.

Agriculture's Share in Total GDP

Rapid industrialization has led to significant structural change in each of these economies. Agriculture's relative importance has declined over time in terms of its share in total GDP in each of the six economies. Though with a tendency to decline relatively to the rest of the economy, agriculture still represents a significantly higher proportion of total GDP in resource-rich Thailand, Malaysia, and Indonesia in the 1990s than in the resource-poor three East Asian economies, where agriculture's GDP shares have rapidly declined to very low levels, particularly in Japan, and Taiwan.

Agriculture's Share in Total Labor Force

Agriculture's relative importance has also declined in terms of its share in total employment in these economies over the past decades. It should be noted, however, that a significantly higher proportion of total labor (50 to 60 percent) is still employed in the agricultural sectors in Thailand and Indonesia in the 1990s. A steep time trend indicates a rapid decline in agriculture's labor share occurred in South Korea and Malaysia. Japan has retained a relatively low share of employment in agriculture since the 1980s. Agriculture's labor share in Taiwan also declined to less than 10 percent in the late 1990s.

Nominal Rate of Agricultural Protection

The nominal rate of agricultural protection is used to represent policy interventions in agriculture. The six economies under study exhibit differences in government policies towards agriculture, which in part reflect the diversity among these economies with respect to agricultural land endowment, stage of economic development, export-promotion or import-substitution industrialization strategy being pursued, and sectoral structure of output and employment. In the postwar period, Japan continued to raise its agricultural protection levels. South Korea and Taiwan lagged behind Japan in the industrialization process and held agricultural producer prices below world prices until the mid-1960s. Thereafter, agricultural protection in South Korea and Taiwan has grown so rapidly that by the early 1980s South Korea's agricultural protection reached levels as high as Japan's. In three Southeast Asian economies, traditional major agricultural exports are often penalized, such as rice and rubber in Thailand, rubber in Malaysia and Indonesia, while import-competing food commodities are less discriminated against and in some cases have modest protection. Since the early 1980s, market liberalization has taken place in these economies. Agricultural price liberalization policy has involved removing agricultural price controls, reducing or eliminating agricultural input and export taxes, eliminating input and credit subsidies, and

²⁶ We omit a detailed discussion on data collection due to space limitation. They may be obtained from the author.

²⁷ The period of rapid economic growth begins late for Thailand, Malaysia, and Indonesia. Earlier data are not available.

dismantling marketing boards. Direct taxation of agricultural exports has become less extreme and protection of import-competing food crops began to increase as these economies developed.

To represent the magnitude of general protection level in agriculture, an index of sector-level agricultural protection for each economy is computed as a weighted arithmetic average of the commodity-specific nominal rates of agricultural protection of the selected commodities, using their shares in the total output value at border prices as weights. The results are shown for the six economies in Figure 1. The results clearly show an overall increasing agricultural protection in Japan, South Korea, and Taiwan over the postwar period. For Thailand, Malaysia, and Indonesia, the trends in average nominal protection levels do not clearly indicate an overall switch from taxing to subsidizing agriculture, while the taxation of major agricultural commodities in these economies has been gradually reduced or removed.

*Indicators of Comparative Advantage in Agriculture*²⁸

Comparative advantage in agriculture is measured by two variables: the factor-endowment (land-capital) ratio; and labor productivity ratio. The factor-endowment or land-capital ratio is the ratio of agricultural land area to total capital stock in an economy. The higher this ratio, the greater an economy's comparative advantage in agriculture. The labor productivity ratio is an index of the ratio of labor productivity in agriculture to labor productivity in nonagriculture.

Estimation Method

For each economy, the simultaneous equations model is estimated by two-stage least squares (2SLS). In the first stage, two endogenous variables: agriculture's relative share, and average nominal rate of agricultural protection, are regressed on all exogenous variables in the system plus a constant term to get the reduced-form parameter estimates used to compute predicted values of the two endogenous variables. In the second stage, each endogenous variable is regressed on a constant term, the predicted value of other endogenous variable, and the exogenous variables included in that equation.

Tests for Exogeneity

Tests for exogeneity (equivalent to 'tests for endogeneity') are used to test whether the variables considered endogenous can be indeed treated as endogenous. For time-series data, tests for Granger causality are the common tests for exogeneity; however, Granger noncausality is neither necessary nor sufficient for exogeneity in the simultaneous equations model (Maddala, 1992, p.394). To test for exogeneity in the simultaneous equations model, Hausman's specification error test is employed (Hausman, 1978). The test procedure is as follows. As an illustration, we rewrite eqs. (*1)-(*2) as

$$y_{1t} = \alpha_0 + \alpha_1 \cdot y_{2t} + \alpha_2 \cdot x_{1t} + \alpha_3 \cdot x_{2t} + \alpha_4 \cdot x_{3t} + \alpha_5 \cdot x_{4t} + \varepsilon_{1t}, \text{ and}$$

$$y_{2t} = \beta_0 + \beta_1 \cdot y_{1t} + \beta_2 \cdot x_{5t} + \beta_3 \cdot x_{6t} + \beta_4 \cdot x_{7t} + \varepsilon_{2t}.$$

We want to test whether y_{2t} and y_{1t} can be treated as an endogenous variable in eq. (*1) and eq. (*2), respectively. First, we obtain the predicted values of y_{2t} and y_{1t} , i.e., \hat{y}_{2t} and \hat{y}_{1t} , respectively, from the reduced-form equations for y_{2t} and y_{1t} . Next, we estimate the following equations (with \hat{y}_{2t} and \hat{y}_{1t} , added to eq. (*1) and eq. (*2), respectively):

$$y_{1t} = \gamma_0 + \gamma_1 \cdot y_{2t} + \gamma_2 \cdot x_{1t} + \gamma_3 \cdot x_{2t} + \gamma_4 \cdot x_{3t} + \gamma_5 \cdot x_{4t} + \gamma_6 \cdot \hat{y}_{2t} + u_{1t}, \text{ and}$$

$$y_{2t} = \theta_0 + \theta_1 \cdot y_{1t} + \theta_2 \cdot x_{5t} + \theta_3 \cdot x_{6t} + \theta_4 \cdot x_{7t} + \theta_5 \cdot \hat{y}_{1t} + u_{2t}$$

²⁸ The agricultural protection coefficients are measures of relative incentives to nonagriculture, while the measures of comparative advantage in agriculture are indicative of relative efficiency to nonagriculture in an international trading setting.

by ordinary least squares estimation (OLS). We then test the null hypothesis: $\gamma_6 = 0$ using the F -test. If the null hypothesis is rejected, y_{2t} can not be treated as exogenous in eq. (*1), and hence would be treated as an endogenous variable. Similarly, the null hypothesis: $\theta_5 = 0$ is tested for y_{1t} in eq. (*2).

As agriculture's relative importance is represented by two variables, agriculture's GDP share and agriculture's labor share, two simultaneous equations models are estimated for each of the six economies. Hence, twelve tests for exogeneity are performed. The test results show that in the case of agriculture's GDP share, South Korea, Taiwan, and Indonesia pass the tests to include agriculture's GDP share and average nominal rate of agricultural protection as two endogenous variables in the simultaneous equations model. In the case of agriculture's labor share, tests are passed by South Korea, Taiwan, and Malaysia to include agriculture's labor share and average nominal rate of agricultural protection as two endogenous variables in the simultaneous equations model. Therefore, there is a total of six cases for the individual-economy estimation.

Tests for Autocorrelation

To test for the presence of serial correlation between the error terms arising in time series data for each individual economy, Durbin-Watson test is employed. If the D-W test rejects the null hypothesis of zero serial correlation against the hypothesis of first-order serial correlation, the estimation is then proceeded by transforming all the variables by ρ -differencing, that is, regress $y_t - \hat{\rho} y_{t-1}$ on $x_t - \hat{\rho} x_{t-1}$, where $\hat{\rho}$ is the estimated first-order correlation coefficient between the estimated residuals $\hat{\varepsilon}_{it}$ and $\hat{\varepsilon}_{it-1}$.

Estimation Results

Tables 4.a-4.b present estimation results of the simultaneous equations model for the cases of agriculture's GDP share.²⁹ In general, the results are satisfactory in terms of the signs of the parameter estimates, most of which are highly significant.³⁰

South Korea

In agriculture's GDP share equation (*1), the estimated parameters of average nominal rate of agricultural protection, and the real per capita GDP, show the expected signs and are significant at the 5% and 10% level, respectively. It is then suggested that endogenously determined higher agricultural protection rates could generate positive policy effects to offset negative growth effects of rising real income per capita on agriculture's relative share as an economy develops.

To prevent agriculture's relative decline in total GDP in the process of economic growth, the rate of agricultural protection needs to be raised by 3.57 percentage points for each \$1,000 increase in real per capita GDP. This is indicated by the estimated coefficients: 10.1598 for average nominal rate of agricultural protection and -0.00363 for real per capita GDP reported in Table 4.a for South Korea. The coefficients of three-year lagged agricultural research expenditures, of agricultural land per capita, and of international terms of trade, show positive signs and are significant at the 10%, 1% and 5% level, respectively.

In agricultural protection equation (*2), the parameter estimate of agriculture's GDP share shows a negative sign and is highly significant at the 1% level in the case of South Korea, thereby confirming the hypothesis that the rate of agricultural protection would increase as agriculture's GDP share declines with economic growth. But protection has not increased enough to keep agriculture's share from falling.

Taiwan

In equation (*1), the parameter estimate of average nominal rate of agricultural protection shows the expected positive sign and is highly significant at the 1% level, indicating a positive policy effect of agricultural protection on agriculture's GDP share. The coefficient of the real per capita GDP has the expected negative sign, although it is not significant, indicating an insignificant

²⁹ The estimation results for the cases of agriculture's labor share are not reported due to space limitation. They are, however, very similar to those for the cases of agriculture's GDP share.

³⁰ The estimation results for Indonesia are not reported due to space limitation.

income effect on agriculture's GDP share. Three other variables in eq. (*1) show positive signs and are all highly significant as expected.

In equation (*2), the coefficient of agriculture's GDP share shows the expected negative sign and is highly significant at the 5% level in the case of Taiwan, suggesting a higher rate of agricultural protection with a smaller agriculture's GDP share with economic growth.

Summary and Conclusions

In this study, we examine the mechanisms through which demand- and supply-side and policy factors affect agriculture's relative share in a growing economy. We conduct simulation and econometric analyses to investigate the effects on agriculture's relative share of both economic and political factors. The simulation results show in all cases a reduction in agricultural policy support, (e.g. due to agricultural trade liberalization) would lead to a lower relative share of agriculture in the total economy. The simulation results indicate also that a higher level of agricultural productivity (e.g. through biotechnology) would result in a larger agricultural sector.

The estimation results of econometric model using data on six Asian economies provide the following useful information. First, agriculture's relative share in total GDP is found to decrease with real per capita GDP, as indicated by a negative coefficient of real per capita GDP in accounting for variations in agriculture's GDP share in South Korea, Taiwan, and Indonesia. Moreover, an economy's GDP share of agriculture appears to decline at higher rates at the early stage of development measured by a low level of real per capita GDP. As the economy develops and its structural change occurs, agriculture's share in total GDP remains declining but at a slower rate than the earlier stage of development. Secondly, positive policy effects of agricultural pricing and trade policies endogenously determined and biased in favor of the agricultural sector as an economy grows are found to offset negative growth effects on agriculture's relative size to some extent. The parameter estimates of average nominal rate of agricultural protection explaining agriculture's share show positive signs in all cases. One may infer that the observed relative shares of agriculture in Japan, Taiwan, and South Korea would have been smaller without support of agriculture being endogenously generated in the context of economic growth. Thirdly, holding other things constant, the estimation results show that agricultural land area per capita has positive impacts on agriculture's relative share in total GDP. This finding confirms that other things being equal agriculture's relative share would be larger in an economy with greater per capita land resources than in a poorly endowed and densely populated economy.

This study has made an attempt to shed light on how economic growth, agricultural policies, and international trade affect agriculture's relative importance in a growing open economy, explicitly taking into account the interrelationship between agriculture's share and policy interventions in agriculture. The adjustment problems arising from agriculture's relative decline have had predictable political consequences as the econometric results explaining protection of agriculture show. In recent years, agricultural trade liberalization pressure, particularly after the Uruguay Round of GATT negotiations and the beginning of the Millennium Round of WTO negotiations, has worked strongly against the domestic demand for agricultural protection through price support and trade barriers. A better understanding of the evolution of the agricultural sector under economic growth may help in formulating economically more sustainable policies in those and other economies.

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Table 1. Definition of the Symbols in the Simulation Model

P_a -- agricultural price	ϕ_{ij} due to technological progress at constant factor prices	demand for good produced in sector j
P_n -- nonagricultural price		
Y_a -- agricultural output	α_{ij} -- share of total input i employed in sector j	ξ_{aa} -- income-compensated own-price elasticity of demand for agricultural good
Y_n -- nonagricultural output	σ_{st}^a -- the Hicks-Allen partial elasticity of substitution between factor s and t in the agricultural sector	ξ_{an} -- income-compensated cross-price elasticity of demand for agricultural good
a -- the agricultural sector	σ^n -- the elasticity of substitution between labor and capital in the nonagricultural sector	ξ_{nn} -- income-compensated own-price elasticity of demand for nonagricultural good
n -- the nonagricultural sector		ξ_{na} -- income-compensated cross-price elasticity of demand for nonagricultural good
L -- labor	C_j -- consumption of good produced in sector j	
K -- capital	M_a -- agricultural imports	δ_j -- self-sufficiency ratio for good produced in sector j
H -- land	X_n -- nonagricultural exports	
ω -- wage rate	η_{jY} -- income elasticity of	$i, s, t = L, K, H; j = a, n$
γ -- rental rate of capital		
π -- rental rate of land		
θ_{ij} -- income (or cost) share of input i in sector j		
ϕ_{ij} -- unit input requirement of input i used in sector j		
λ_{ij} -- proportionate reduction in		

Table 2. Assumed Exogenous Parameter Values

θ_{La} 0.35	θ_{Kn} 0.70	α_{Kn} 0.85	σ_{KK}^a -2.0	ξ_{aa} -0.16	η_{aY} 0.30
θ_{Ka} 0.20	α_{La} 0.20	σ_{LL}^a -0.93	σ_{HK}^a 0.5	ξ_{an} 0.16	η_{nY} 1.25
θ_{Ha} 0.45	α_{Ln} 0.80	σ_{KL}^a 0.50	σ_{HH}^a -0.61	ξ_{na} 0.04	
θ_{Ln} 0.30	α_{Ka} 0.15	σ_{HL}^a 0.50	σ_{KL}^n 0.50	ξ_{nn} -0.04	

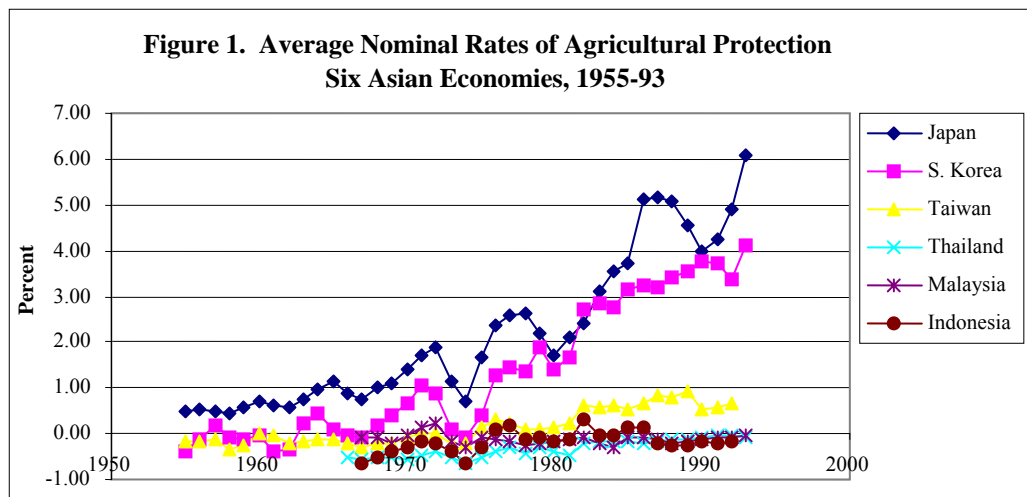


Table 3. Simulated Effects of Agricultural Price Support on Agriculture's GDP Share in an Agricultural-Importing Developed Economy

	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Exogenous Variables (in rate of change)					
Agricultural Price, P_a	0.10	0.20	0.30	0.30	0.50
Nonagricultural Price, P_n	0.10	0.10	0.10	0.10	0.10
Labor, L	0.018	0.018	0.018	0.018	0.018
Capital, K	0.1	0.1	0.1	0.1	0.1
Land, H	0	0	0	0	0
Technological Change in Agriculture, λ_{La}	0.08	0.08	0.08	0.12	0.12
Technological Change in Agriculture, λ_{Ka}	0.08	0.08	0.08	0.12	0.12
Technological Change in Agriculture, λ_{Ha}	0.08	0.08	0.08	0.12	0.12
Technological Change in Nonagriculture, λ_{Ln}	0.12	0.12	0.12	0.12	0.12
Technological Change in Nonagriculture, λ_{Kn}	0.12	0.12	0.12	0.12	0.12
Endogenous Variables (in rate of change)					
Wage Rate, ω	0.0895	0.0986	0.1077	0.1041	0.1222
Rental Price of Capital, γ	-0.0669	-0.0708	-0.0747	-0.0732	-0.0810
Rental Price of Land, π	0.0046	0.2215	0.4383	0.3516	0.7854
Agricultural Output, Y_a	0.0723	0.1307	0.1892	0.2058	0.3227
Nonagricultural Output, Y_n	0.2079	0.1864	0.1650	0.1736	0.1307
Agricultural Consumption, C_a	0.0840	0.0792	0.0743	0.0818	0.0720
Nonagricultural Consumption, C_n	0.3502	0.4005	0.4507	0.4822	0.5828
Labor employed in Agriculture, L_a	-0.0773	0.0720	0.2214	0.1616	0.4603
Labor employed in Nonagriculture, L_n	-0.0138	-0.0437	-0.0736	-0.0616	-0.1213
Capital used in Agriculture, K_a	0.0792	0.2416	0.4039	0.3390	0.6636
Capital used in Nonagriculture, K_n	0.1426	0.1257	0.1089	0.1156	0.0818
Initial Values					
P_a^0	1.00	1.00	1.00	1.00	1.00
P_n^0	10.00	10.00	10.00	10.00	10.00
Y_a^0	114,556	114,556	114,556	114,556	114,556
Y_n^0	137,650	137,650	137,650	137,650	137,650
$\Delta P_a = P_a^0 \cdot \text{rate of change in } P_a$	0.10	0.20	0.30	0.30	0.50
$\Delta P_n = P_n^0 \cdot \text{rate of change in } P_n$	1.00	1.00	1.00	1.00	1.00
$\Delta Y_a = Y_a^0 \cdot \text{rate of change in } Y_a$	8,281	14,976	21,671	23,575	36,965
$\Delta Y_n = Y_n^0 \cdot \text{rate of change in } Y_n$	28,614	25,664	22,714	23,894	17,995
$P_a^1 = P_a^0 + \Delta P_a$	1.10	1.20	1.30	1.30	1.50
$P_n^1 = P_n^0 + \Delta P_n$	11.00	11.00	11.00	11.00	11.00
$Y_a^1 = Y_a^0 + \Delta Y_a$	122,837	129,532	136,227	138,131	151,521
$Y_n^1 = Y_n^0 + \Delta Y_n$	166,264	163,314	160,365	161,544	155,645
Agricultural GDP = $P_a^1 \cdot Y_a^1$	135,121	155,438	177,095	179,570	227,281
Nonagricultural GDP = $P_n^1 \cdot Y_n^1$	1,828,902	1,796,457	1,764,010	1,776,989	1,712,097
Nominal Total GDP = $P_a^1 \cdot Y_a^1 + P_n^1 \cdot Y_n^1$	1,964,022	1,951,895	1,941,104	1,956,559	1,939,378
Real Total GDP = $P_a^0 \cdot Y_a^1 + P_n^0 \cdot Y_n^1$	1,785,475	1,762,674	1,739,872	1,753,576	1,707,972
Agriculture's GDP Share	0.0688	0.0796	0.0912	0.0918	0.1172

Note: Economy example is Taiwan, with agriculture's GDP share of 7.68 percent and real total GDP of 1,491,059 millions of New Taiwan Dollar (NT\$) in 1980.

**Table 4.a Parameter Estimates of the Simultaneous Equations
Model of Agriculture's GDP Share, S. KOREA, 1955-96**

Equation (6.2.1) AgGDP%		Equation (6.2.2) ANRAP	
Explanatory Variables		Explanatory Variables	
Intercept	- 118.943 (46.271)**	Intercept	1.079 (0.715)
ANRAP	10.1598 (4.9651)**	AgGDP%	- 0.177 (0.051)***
RpcGDP	- 0.00363 (0.002004)*	LaborProdR	8.324 (3.445)**
AgResLg	0.574 (0.310)*	FtEndowR	6.717 (11.810)
AgLandPC	1844.236 (577.158)***	SelfSfCLg	- 0.966 (1.352)
IATOT	37.628 (17.832)**		
D-W, N=26	1.88	D-W, N=26	1.47
Adjusted R ²	0.86	Adjusted R ²	0.76

Note: AgGDP%: Agriculture's Share in Total GDP;
ANRAP: Average Nominal Rate of Agricultural Protection;
RpcGDP: Real Per Capita GDP;
AgResLg: Agricultural Research Expenditures, 3-yr lagged;
AgLandPC: Agricultural Land Per Capita;
IATOT: International Agricultural Terms of Trade;
LaborProdR: Labor Productivity Ratio;
FtEndowR: Factor-Endowment (Land-Capital) Ratio; and
SelfSfCLg: Self Sufficiency Rate in Cereals, 3-yr lagged.

Note: Standard errors are in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.
*** denotes significance at the 1% level.

**Table 4.b Parameter Estimates of the Simultaneous Equations
Model of Agriculture's GDP Share, TAIWAN, 1955-96**

Equation (6.2.1) AgGDP%		Equation (6.2.2) ANRAP	
Explanatory Variables		Explanatory Variables	
Intercept	- 50.078 (7.972)***	Intercept	- 0.328 (0.320)
ANRAP	8.5476 (2.4802)***	AgGDP%	- 0.286 (0.137)**
RpcGDP	- 0.000997 (0.000709)	LaborProdR	8.125 (3.539)**
AgResLg	0.331 (0.162)**	FtEndowR	63.947 (38.472)
AgLandPC	976.704 (93.406)***	SelfSfCLg	- 0.762 (0.910)
IATOT	8.933 (3.877)**		
D-W, N=26	1.80	D-W, N=26	1.41
Adjusted R ²	0.97	Adjusted R ²	0.36

Note: AgGDP%: Agriculture's Share in Total GDP;
ANRAP: Average Nominal Rate of Agricultural Protection;
RpcGDP: Real Per Capita GDP;
AgResLg: Agricultural Research Expenditures, 3-yr lagged;
AgLandPC: Agricultural Land Per Capita;
IATOT: International Agricultural Terms of Trade;
LaborProdR: Labor Productivity Ratio;
FtEndowR: Factor-Endowment (Land-Capital) Ratio; and
SelfSfCLg: Self Sufficiency Rate in Cereals, 3-yr lagged.

Note: Standard errors are in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.
*** denotes significance at the 1% level.